Does exist a real commitment to diminish GHG emissions by developed countries?: a study of USA and Germany, 2000-2010

Javier Castañeda León[1]

Abstract

The upward growth rates of Green House Gases (GHG) have generated the need of several agreements to reduce those emissions, especially considering their importance about climate change. Nevertheless, some developed countries do not have a real commitment in the diminishment of such emissions, due to the fact that event when they diminish their domestic emissions, indirectly contribute to GHG generation. Later implies that current emissions account does not reflect necessarily the real commitment of countries to abate pollution.

This paper studies how developed countries generate emissions indirectly by importing goods which production is highly polluting and also providing high polluting inputs for industrial processes. Using Muti-Regional Input-Output matrices and GHG vectors, are estimated matrices that show GHG induced by the foreign value added to export and balances of emissions between some regions of the world.

Resumen

El incremento global de los Gases de Efecto Invernadero (GEI) ha generado la necesidad de crear diversos acuerdos para reducir dichas emisiones, especialmente por la importancia que tienen sobre el cambio climático. No obstante, algunos países desarrollados no tienen un compromiso real con la reducción de dichas emisiones, debido a que, si bien han disminuido sus emisiones domésticas, indirectamente contribuyen en su generación. Lo anterior implica que la contabilidad actual de las emisiones no necesariamente refleja el compromiso real de los países para disminuir los GEI.

En el presente artículo se estudia cómo los países desarrollados generan emisiones indirectamente mediante la importación de bienes cuya producción es altamente contaminante, así como mediante los insumos que suministra para los procesos

[1] PHD student, Faculty of Economics, National Autonomous University of Mexico (UNAM), calj07@hotmail.com

productivos. Mediante el uso de Matrices Multi-regionales de Insumo-producto y vectores de GEI se calculan GEI inducidos por el valor agregado foráneo para exportar; y balanzas de emisiones de Estados Unidos y Alemania con algunos países seleccionados.

Introduction

Trade liberalization processes which intensified in the 1990s, resulted in a restructuring of international trade. This process was accompanied by a change of the production structure of goods and services due to the increasing involvement of transnational corporations through horizontal organization of production, in which inputs and production phases are developed in several countries to made a final product, a process better known as global production chains (GPC).

Therefore trade liberalization and especially the GPC have offered several advantages and disadvantages to each country. In some countries, whose economic growth depends heavily on exports, they have been favored by the significant increase in international trade, in other countries the place of some of its productive sectors take up within global production chains offered them advantages in the generation of value added and consequently improved the living standards of its population.

On the other hand one of the main disadvantages of the GPC and world trade are negative externalities, in which one of the most important is the generation of emissions of greenhouse gases (GHG). In consequence the academic and government research regarding to GHG generation has increased in recent years due to its influence on climate change.

For that reason the several agreements to reduce GHG emissions headed by the Kyoto Protocol, are important elements that influence the dynamics of world trade and GPC, especially considering that the GHG accounting is closely linked to the territory and sovereignty of countries[2].

This last aspect is very important, because both countries and companies seek the conditions that give them less environmental costs, either by international agreements or by environmental regulation of countries.

Despite this, when emissions generated in the production process are studied, it must take special care with two elements, the first is that many of these emissions are generated by the use of inputs inefficient in environmental terms, the second is that a percentage of

[2] The total GHG emissions refer to the emissions and absorptions within the jurisdiction scope of national Sovereignty (Pang J. et al,2012)

emissions induced by the production processes are generated for production of goods and services that have as destination another country.

The objective of this research is to study the direct and indirect responsibility of some developed countries in the GHG generation related to the production processes of goods and services involved in international trade. This under the hypothesis that the estimation of emissions by territory do not reflect the full effect on its generation, countries like the USA and Germany are net importers of GHG emissions, even when their reported emissions has diminished.

Section 2 presents some considerations on greenhouse gas emissions measurement, in section 3 are describe data and methodology, in section 4 are shown the results obtained for United States and Germany compared with selected countries, finally in section 5 some conclusions are discussed.

2.- Some considerations about GHG measurement

As with economic statistics, environmental data associated with the production of goods and services must be supplemented with additional information to get an analysis closer to reality. Below are presented some examples in order to show the importance of GHGs measurement for its study, as well as new and better ways of measurement.

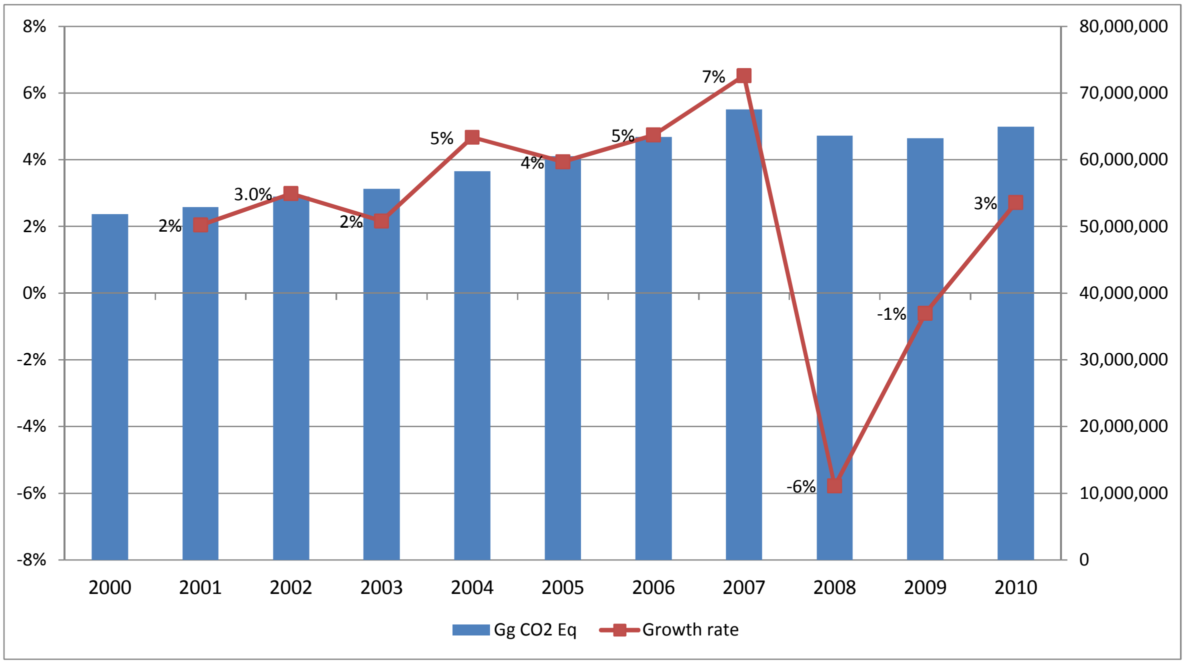
In Figure 1 are observed the global GHG emissions of 2000 and 2010 with their respective growth rates. If we focus to the gigagrams -thousand of tons- of GHG (the bars graphs) shows that broadly emissions have remained constant, with few increases during the period especially in 2004 and 2007 and a considerable diminishment in 2008. During the period GHGs emissions increase 25% from 2000 to 2010, but it's not very clear at first sight. Nevertheless, if the data is verified from a different perspective that is in terms of their growth rates, the results show longer increases and decreases (7% in 2007 and -6% in 2008) than those that at first glance could be seen in the bars.

Another important point that is desirable to observe, is that the increase of GHG emissions in China in recent years, despite the best efforts of many countries to accomplish the Kyoto Protocol, has maintained steady global emissions of GHGs. Moreover, in some particular cases such as the increased emissions in Brazil until 2005 due to excessive logging and its subsequent decline in the following years[3], also are not reflected. That is, given the amount of global GHG emissions, the diminishment of 304.600 Giga grams of CO2eq. in Brazil from 2005 to 2006, represent just under 0.5% of global emissions in the last year.

[3] "Between 2005 and 2010, Brazil's greenhouse gas emissions plunged by 39 percent, declining faster than in any other country. Brazil accomplished this by slashing its deforestation rate by more than three-quarters, mostly in the Amazon basin." Schiffman, R.(2015)

Figure 1. World GHGs Emissions,

2000-2010, (Gigagrams of CO2 equivalent and growth rates)

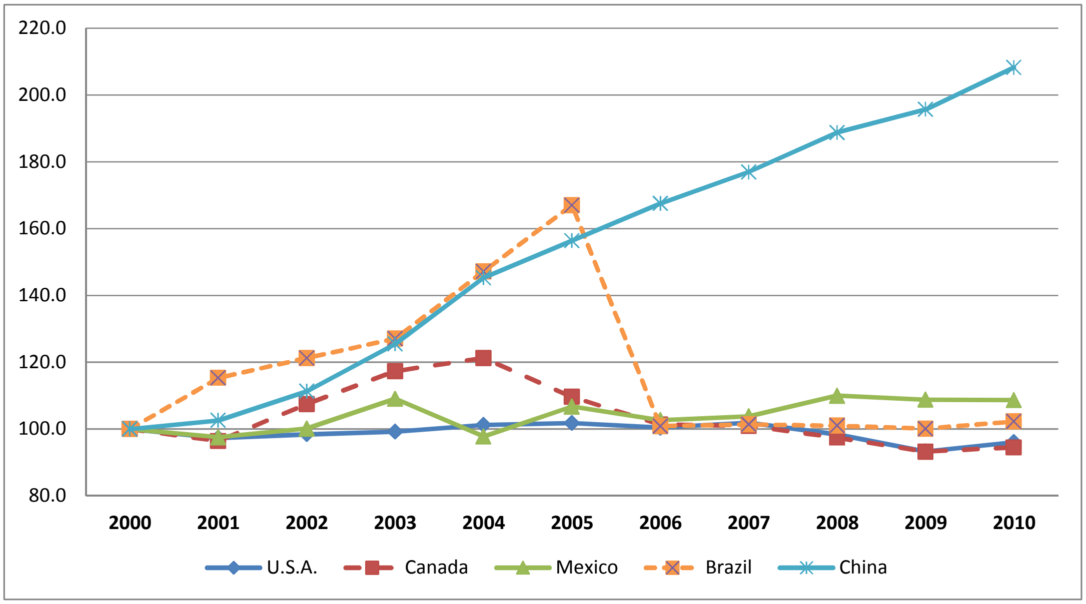


Source: Author's calculations based on data from EORA-UNCTAD

In Figures 2 and 3 it can be shown the noted above. In Figure 2, despite the increase in Brazil's emissions from 2000, all countries except China maintain the same emissions that in the base year. Nonetheless, this does not mean that countries diminish these emissions by reducing production[4]. This is clearer because data for the period 2008-2009 (during the global crisis) shows only slightly diminishments in developed countries and Russia, which possibly represent an attributable effect to negative economic growth rates. In the case of China, the results do not necessarily mean that this country has not implemented measures to make production more efficient with respect to the GHG generation, as can be observed in Figure 4.

[4] According Pan et all (2008) Changes in emissions generated in production proceses can be decomposed in: “a) a technique effect from changes in the emissions intensity of production; b) a composition effect, reflecting the share of ‘dirty’ versus ‘clean’ sectors in total output; and c) a scale effect from the growth or contraction of the economy”.

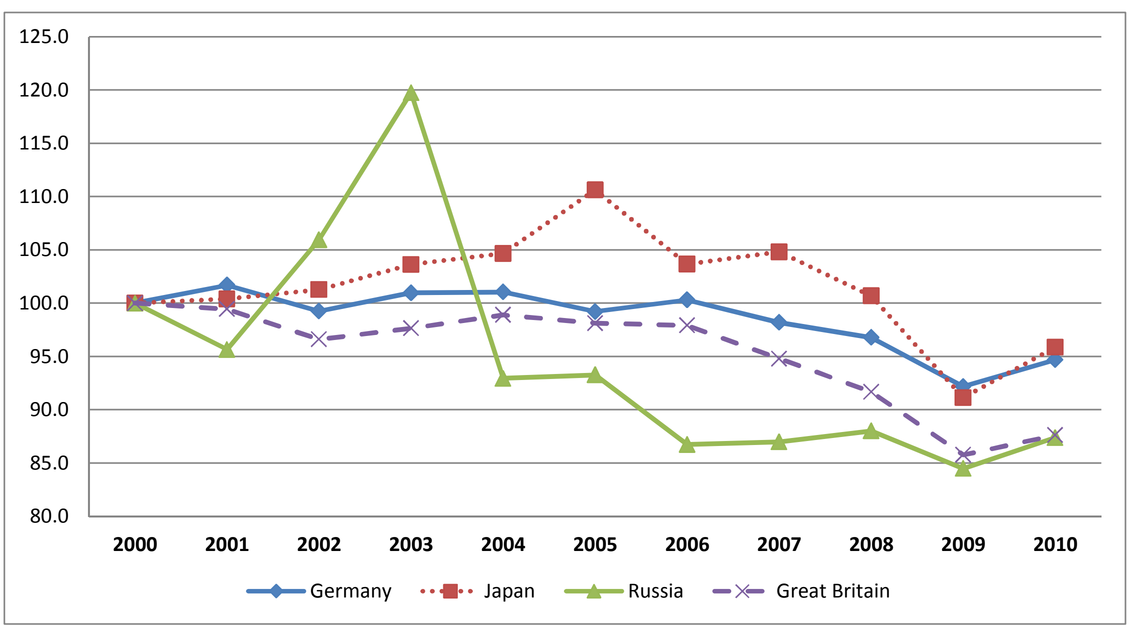
Figure 2. GHG generation 2000=100, selected countries



Source: Author's calculations based on data from EORA-UNCTAD

Another element that attracts attention is that the developed countries in Europe and Asia, excluding China and Russia, are the most committed with respect to the reduction of emissions. In this regard, the cases of Britain and Russia are highlighted with a nearly 14% diminishment in 10 years. These diminishments contrast with the increase of over 100% of China's emissions.

Figure 3. GHG generation 2000=100, selected countries



Source: Author's calculations based on data from EORA-UNCTAD

Until now the evidence shows that all countries of the sample make significant efforts to reduce their emissions, except China. Even more, as seen in Table 1, the share of developed countries and Russia in the global GHG emissions has decreased by 8% and 5% respectively, while China's share has increased by 14%.

Table 1. World GHG emissions (percentages**)**

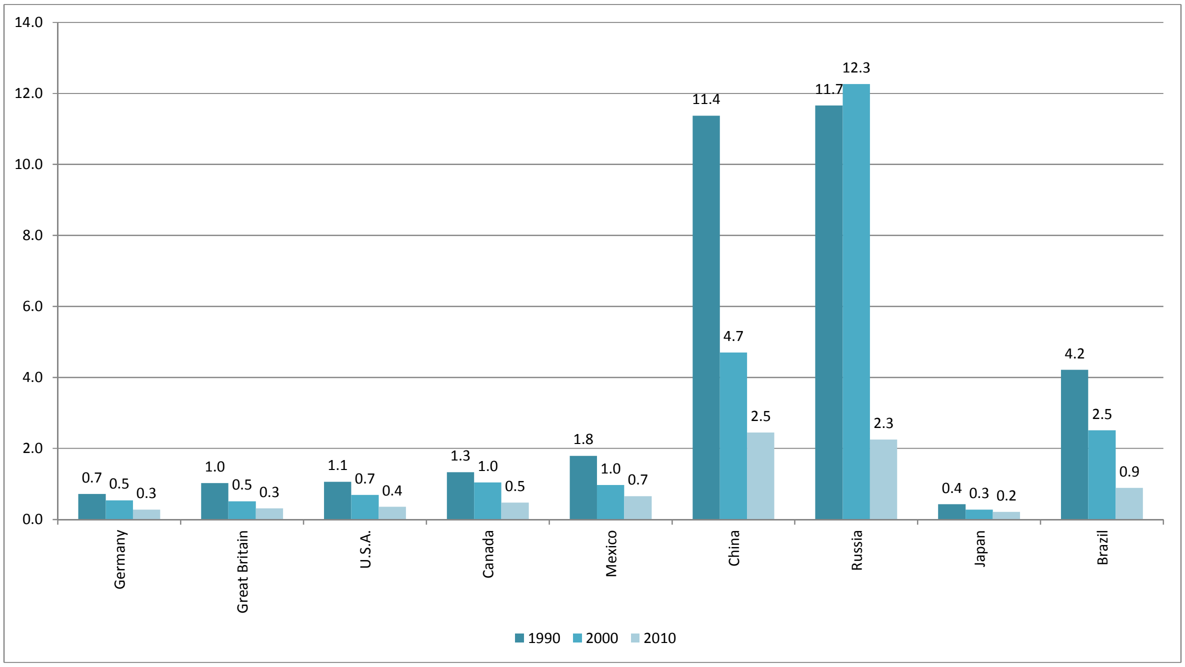
	1990	2000	2010
Developed Countries	**35.23**	**35.08**	**27.19**
U.S.A.	19.40	20.52	15.76
Germany	3.53	2.78	2.16
Rest of Europe Union	8.50	8.14	6.29
Japan	3.80	3.64	2.97
Developing Countries	**46.84**	**48.50**	**59.23**
Latin America and the Caribbean	10.62	10.13	9.36
Mexico	1.66	1.83	1.64
Rest of Asia	12.00	14.77	16.56
China	13.48	15.89	27.44
Russia	10.74	7.71	5.87
Other countries	**17.93**	**16.42**	**13.58**
Total	**100.00**	**100.00**	**100.00**

Source: Author's calculations based on data from EORA-UNCTAD

Nevertheless, when data are viewed from a third perspective seem to show very different results. Figure 4 presents kilograms of CO2 equivalent per dollar produced, in all cases the results of this indicator show significant improvement in production efficiency in terms of GHG emissions in 20 years, even in the case of China when reduce 22% the emissions by product from 1990 to 2010.

Figure 4. GHG emissions per dollar produced,

(Kilogram of de CO2eq./dollar produced)



Source: Author's calculations based on data from EORA-UNCTAD

Last figure undoubtedly difficult to obtain any conclusions until now, even in the cases of China and the United States, two of the largest GHG emitters. To solve such problems there are several proposals from researchers in the field.

These proposals can be divided into two wide categories, the downstream responsibility and upstream responsibility. Downstream responsibility implies that the supply of factors of production enables the generation of GHG emissions, in the other hand, upstream responsibility implies that the demand for goods and services enables the generation of GHG emissions (Lenzen and Murray, 2010).

Usually must common analyses of emissions are with respect of upstream. Nevertheless, some authors as (Pan, J. et all, 2008), (Pang, J. et all, 2012) proposed that measurement should be carried out also considering downstream responsibility, not separately, but set a joint measurement to achieve closer results to reality.

However, within the upstream responsibility there are still elements to consider, which even without using the downstream would provide more adequate results on accounting for GHG which each country contribute to generate. Within GPC, production processes are carried out in different countries, so in the same way the inputs come from various parts of the world and also the final goods and services are distributed around the world for final consumption, it is said that these processes have embodied emissions.

In this sense, the emissions generated by the use of imported inputs and the emissions generated for the production of exported goods and services, have intrinsic responsibility that should be shared by the countries of origin of the inputs and the countries that are targeted final goods and services exported.

In the following section are presented two methodologies that allow quantifying these elements for a sample of 8 countries, with main emphasis on the United States and Germany.

3. Database and Methodology

De database used consist in multiregional input-output matrices (MRIO) of the Word Input-Output Database (WIOD) and vectors of GHG emissions expressed in CO2 equivalent[5] from the Eora-UNCTAD database, the same data have been used to quantify the statistics presented in the previous section.

3.1 GHG embodied in exports

Follow Castañeda y Vivanco (2014) to elaborate a multiregional GHG to export matrix, with the purpose of study how the use of imported inputs influence in the generation of GHG of U.S.A and Germany.

The methodology starts from the standard relation for input-output analysis to the entire economic system (Miller and Blair, 2009, p. 20)

$$\boldsymbol{Z} * \boldsymbol{i} + \boldsymbol{f} = \boldsymbol{x} \qquad \textbf{1}$$

Where:

X: inter-industrial transactions matrix
i: identity vector
f: final demand vector
x: total output vector; vectors are written as columns

From basic expression (Equation 1), by a vector “g” of GHG is obtained $\mathrm{L} = \widehat{\mathrm{gx}}^{-1}$, where ^ means that the vectors have been transformed in diagonal matrices, and represents a coefficient matrix of the units of GHG generated by unit of gross output.

---

[5] GHG data include al green house gases expresed in CO2 equivalent, as well as land use land use change

When each member of (1) is multiplied by L, to maintain the equality, we obtain

$$\widehat{gx}^{-1}(\boldsymbol{X} * \boldsymbol{I} + \boldsymbol{f}) = \widehat{gx}^{-1}\boldsymbol{x} \quad \textbf{2}$$

or the same

$$\boldsymbol{LX} * \boldsymbol{I} + \boldsymbol{Lf} = \widehat{gx}^{-1}\widehat{\boldsymbol{x}} \quad \textbf{3}$$

Due that $\widehat{\boldsymbol{x}}^{-1}\boldsymbol{x} = \boldsymbol{I}$ and $\widehat{\boldsymbol{g}}^{-1}\widehat{\boldsymbol{g}} = \boldsymbol{i}$

We can rewrite the expression (3) as:

$$\boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1}\widehat{\boldsymbol{g}} + \boldsymbol{Lf} = \boldsymbol{gI} \quad 4$$

Reordering and solving for $\boldsymbol{Lf}$:

$$\boldsymbol{Lf} = \widehat{\boldsymbol{g}}\boldsymbol{I} - \boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1}\widehat{\boldsymbol{g}} \quad 5$$

$$\boldsymbol{Lf} = (\boldsymbol{I} - \boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1})\widehat{\boldsymbol{g}} \quad 6$$

Isolating $\widehat{\boldsymbol{g}}$ as a diagonalized vector now called G, which will now be our GHG emissions vector:

$$(\boldsymbol{I} - \boldsymbol{LX} * \widehat{\boldsymbol{g}}^{-1})^{-1}\boldsymbol{Lf} = \widehat{\boldsymbol{g}} = \boldsymbol{G} \quad 7$$

For the result of 7 be a diagonal matrix, **f** must be a diagonal vector of final demand

If we define $\mathrm{E} = LX * \hat{g}^{-1}$

Then we can rewrite equation 7 as

$$(\boldsymbol{I} - \mathbf{E})^{-1}\boldsymbol{Lf} = \boldsymbol{G} \quad 8$$

Where $(\mathrm{I} - \mathrm{E})^{-1}$, when we use both L and F in matrix form (diagonal matrix) it allows to generate a matrix of direct and indirect GHG coefficients "G".

This expression is similar to the orthodox way to get a matrix of emissions using the following equation:

$$\widehat{\boldsymbol{g}}(\boldsymbol{I} - \boldsymbol{A})^{-1}\widehat{\boldsymbol{f}} = \boldsymbol{G} = (\boldsymbol{I} - \mathbf{E})^{-1}\boldsymbol{LF} \quad \textbf{9}$$

3.2 GHG balance

GHG balance consist in verify within the actual quantification of emissions, the real responsibility of the countries generated by supply and demand of goods and services in trade. That is, how many GHGs are generated to produce goods and services that are exported and how many GHG are indirectly generated[6] by the import of goods and services to satisfy domestic consumption in the country of study, so that:

[6] Which usually are registered in other countries GHG accounting

$$G^{ab} = E^{a}(I - A^{a})^{-1}X^{ab} \quad 10$$

$$G^{ba} = E^{b}(I - A^{b})^{-1}X^{ba} \quad 11$$

Where "E" is a GHG coefficients vector (GHG/Gross Output)

X^{ab} are exports from country "a" to country "b"; X^{ba} are exports from country "b" to country "a". Therefore GHG balance of "a" with "b" $= G^{ab} - G^{ba}$

This methodology could present disadvantages mainly related to lack of information. Nevertheless, this research takes the information of the MRIO and NIOT of each country, allowing complete information on the flows of inputs and final goods and services between countries, production structure and emission coefficients of each sector in the countries studied.

4. GHG embodied in exports and GHG balance results

GHG emissions unlike other externalities, regardless of which country produces them, emissions inevitably reach the atmosphere and affect the entire world. Therefore it is convenient to analyze how countries influence their generation, so that GHG accounting should reflect emissions generation by both upstream[7] and downstream responsibility of countries, but also emissions generated indirectly by consumption of imported goods and services.

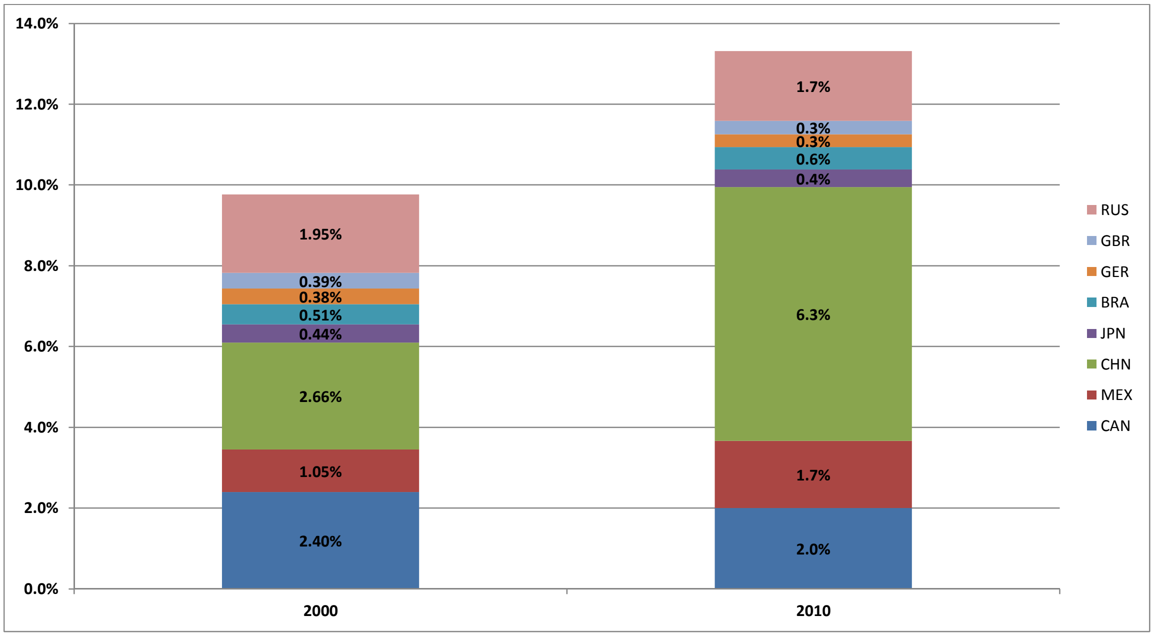
In this sense, the trade flows of the countries generate GHG embodied in exports and imports, and therefore net emissions. GHG emissions embodied in exports consider the use of inputs that may be domestic or imported. However, since production processes generate linkages within the country and abroad, these same productive linkages also are associated with the GHG generation. That is, with the production of a good there are also internal and external GHG linkages so that a conventional measurement of emissions by using NIOTS could not see all the effects.

In Figure 5 are observed the United States emissions generated to produce exports by using imported inputs. In 2000, most of these emissions are generated using inputs from China, Canada and Russia, which account for 2.66%, 2.40% and 1.95% respectively. Of all emissions generated in this issue by the United States en 2010, 6.3% are generated by the use of inputs from China. Additionally, the emissions generated to produce exports using

[7] Production based accounting approach (resulting from upstream approach) ignores the phenomenon of *carbon leakage*. “Carbon leakage occurs when a country is able to reduce its greenhouse gas inventories by importing goods from another country”.(Liu, Jayanthakumaran and Neri, 2012, p.p.3)

imported inputs account for 22.1% (8.8% corresponds to the rest of the world) of the total emissions generated by the production of exports from United States in 2010[8].

Figure 5. United States: GHG generated to produce exports by using imported inputs, 2000, 2010, (percentages)



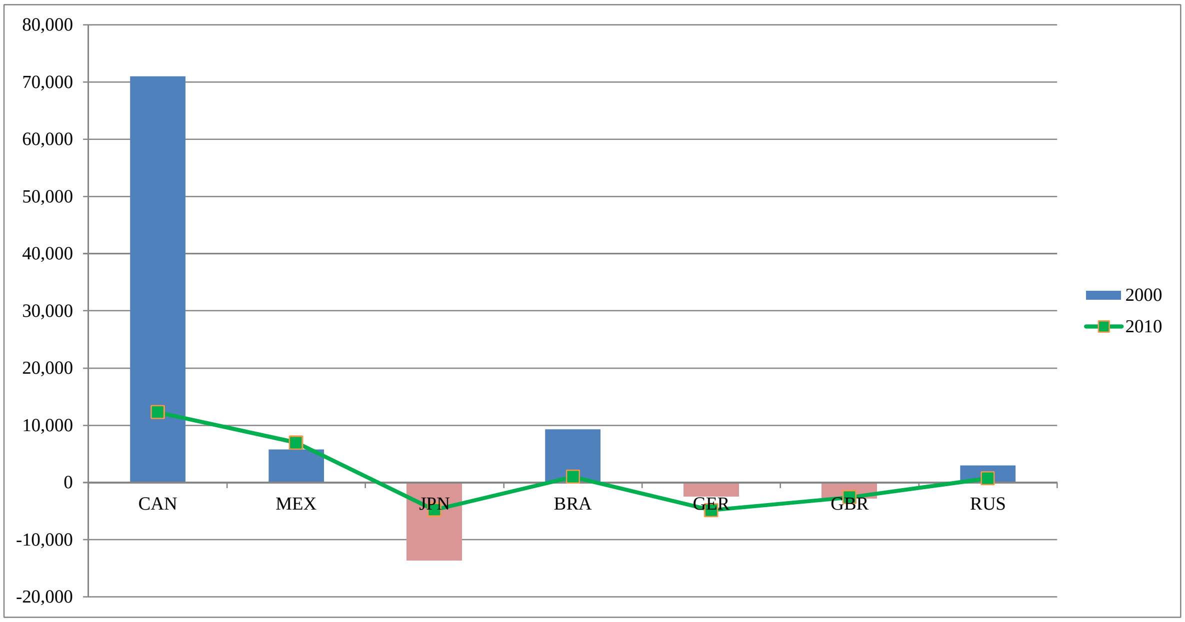
Source: Author's calculations based on data from EORA-UNCTAD and WIOD

On the other hand, GHG indirect generation of United States through the consumption of imported goods has a positive balance with Canada, that is, the United States generates more emissions indirectly by importing goods and services from Canada than those generated to produce exports targeting Canada (see figure 6).

[8] In 1990, GHG generated to produce exports using imported inputs in United State represented 19.4% of total del total GHG generated to produce exports.

Figure 6. United States: GHG balance with selected countries,

2000,2010, (Gigagrams of CO2 equivalent)



Source: Author's calculations based on data from EORA-UNCTAD and WIOD

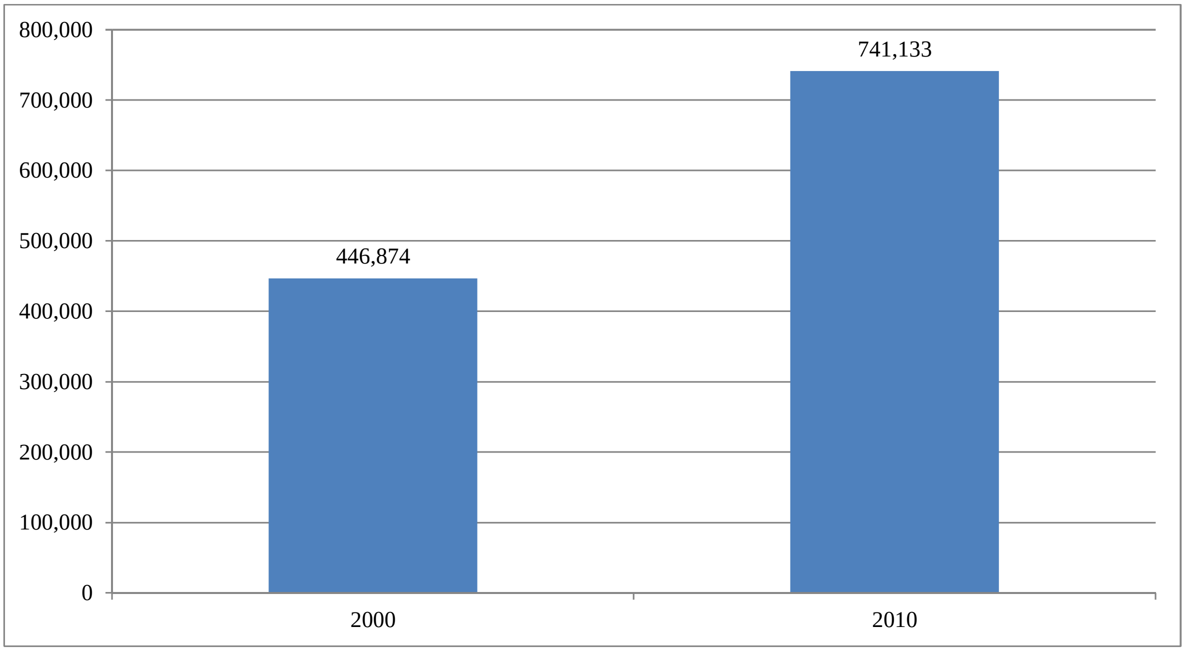
This indicator is even more important when results with China are analyzed because the United States is a net importer of emissions with China in 2000, and these results are increased by 70% by 2010 (see Figure 7). That is, of the 12.6 million gigagrams of CO2eq. generated by China in 2010, 741, 000 were for a surplus in the production of goods and services generated by the demand for imports from the United States (see Figure 7), the foregoing without considering emissions generated by China for the use of inputs from United States. On the other hand, of the 7.3 million gigagrams of CO2eq. which led the United States to produce goods and services in 2010, 882.894 were to produce its exports, within which 5,000 (6.5%) were for the use of inputs imported from China (see figure 5) [9].

---

[9] The results are consistent with those presented by Shui and Harris (2006) in which conclude that between 7% and 14% of CO2 emissions of China are attributable to USA (in Liu, Jayanthakumaran and Neri, 2012, p.p.8)

Figure 7. GHG balance of United States with China,

2000,2010, (Gigagrams of CO2 equivalent)

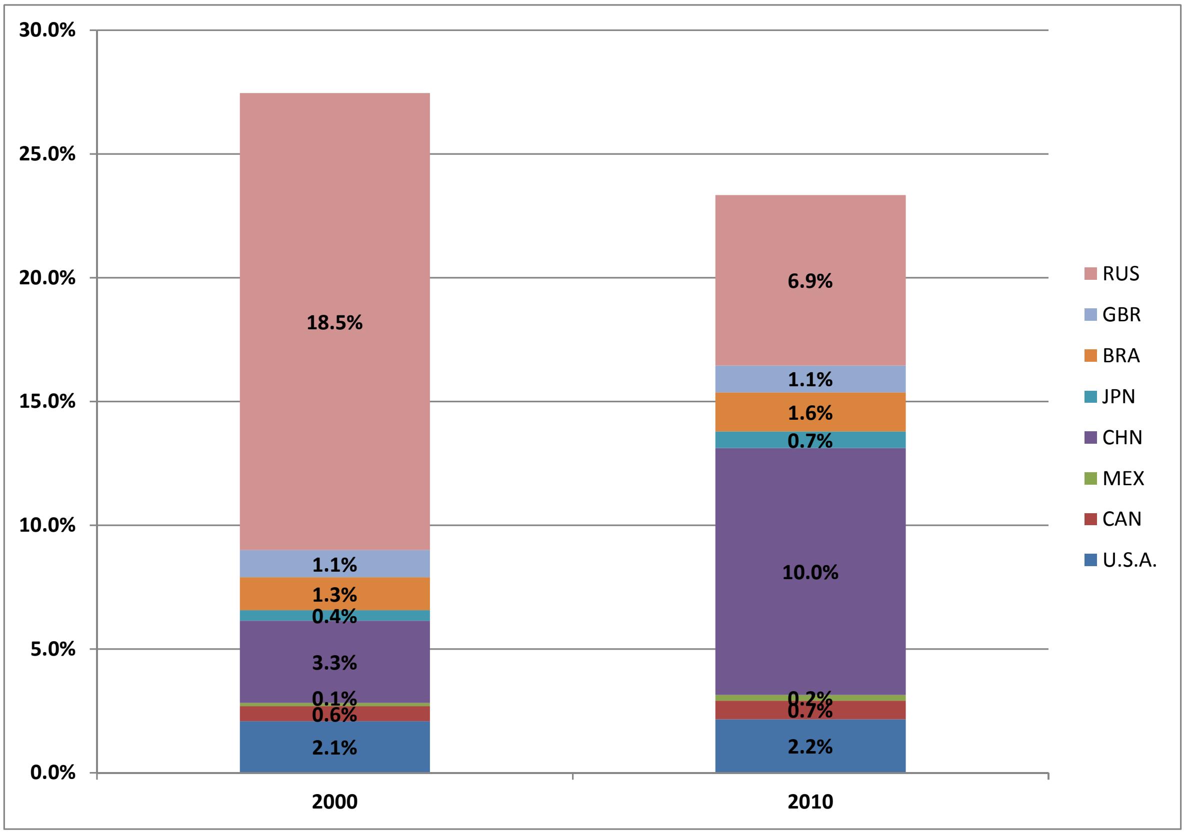


Source: Author's calculations based on data from EORA-UNCTAD and WIOD

Meanwhile from the total emissions generated to produce exports in Germany in 2000, 18.5% were for by using inputs from Russia, while 3.3% of these emissions were by using imported inputs for China and 2.2% for the use of imported inputs from the United States. This situation is reversed in 2010 where the use of inputs from Russia, China and the United States generated 6.9%, 10% and 2.2% of GHG to produce exports of Germany respectively (see Figure 8).

On the other hand it is important to underline that in both years of study over 50% of generated to produce exports of Germany were by using imported inputs, 52.4% in 2000 (24.9% corresponds to the rest of the world) and 52.6% in 2010 (24.9% corresponds to the rest of the world).

Figure 8. Germany: GHG generated to produce exports by using imported inputs, 2000, 2010, (percentages)

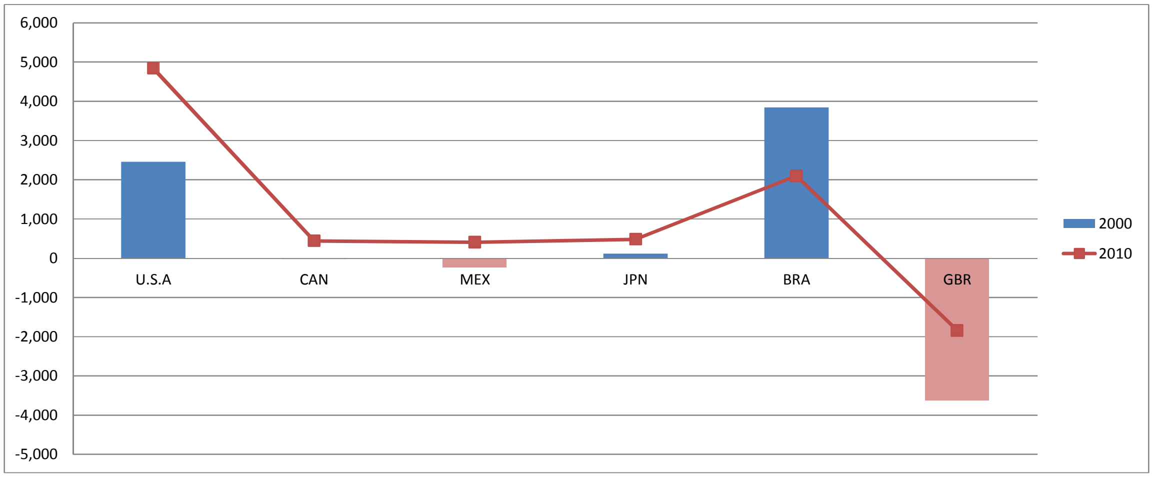


Source: Author's calculations based on data from EORA-UNCTAD and WIOD

In the GHG balance of Germany highlights the increase in the positive balance with the United States in 2010 and a deficit with Great Britain. In the first case it involves a bigger generation of GHG indirectly by importing goods and services from USA that GHG generated to produce exports from USA to Germanys demand. In the second case involves a greater responsibility in the generation of GHG by the production of goods and services that are part of the trade between the Great Britain and Germany (see Figure 9).

Figure 9. Germany: GHG balance with selected countries,

2000,2010, (Gigagrams of CO2 equivalent)



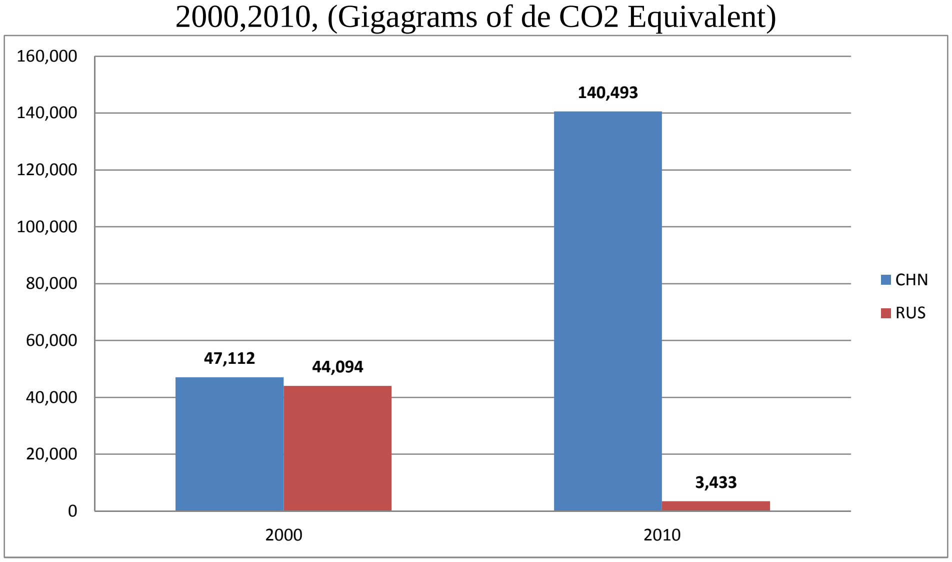
Source: Author's calculations based on data from EORA-UNCTAD and WIOD

Nonetheless, Figure 10 shows that the most relevant cases in GHG balance of Germany are with Russia and China. In the first case from having a high positive balance it decreased to an insignificant amount, which bounded with previous results in Figure 8 could be due to a decrease in trade flows between both countries.

In the case of Germany with China, the surplus on the GHG balance increased by almost 200%, that is, of total emissions from China in 2010, at least 140.493 gigagrams CO2eq. could be attributed to Germany.

Figure 10. GHG balance of Germany with China and Russia,

2000,2010, (Gigagrams of de CO2 Equivalent)



Source: Author's calculations based on data from EORA-UNCTAD and WIOD

Concluding remarks:

The results about GHG generation of GHG by using imported inputs and GHG balances show how the current accounting of GHG emissions of countries do not clearly reflect the real responsibility of each country in the generation of emissions .

In the US case, it appears that its real commitment on GHG generation is far from what the actual emissions accounting shows, because about 80% of the emissions to produce exports correspond to the use of inputs domestic, that is, the liability that may be shared with other countries is only 20% in this category.

With respect to the GHG balance, US has a high indirect emissions generation particularly with its trading partners of North American Free Trade Agreement (NAFTA) and China. This means that if the over 760,000 Gg CO2 eq. of surplus with these three countries where added to the United States GHG account, total US emissions would increase by 10%. Likewise if the surplus of the GHG balance were subtracted from China´s GHG account, these would decrease by 5%.

Meanwhile Germany shows greater commitment in reducing GHG emissions that United States. The generation of emission by using imported inputs reflects greater trade opening and greater participation in the GPC, which remains constant in the study period. Despite this, the growing dependence on inputs from China implies a shared responsibility in this issue with respect to the GHG generation with such country.

Nevertheless, the surplus of GHG balance with China shows that the indirect GHG generation of Germany by importing goods and services from China is higher than the emissions generated in Germany by the use of imported inputs from China. In this sense, considering the two measurements, there is a greater amount of GHGs that should be accounted to Germany and that would mean a reduction in emissions data reported for China.

In general, the analysis made in this work could be complemented with other elements for an even more accurate study, such as an analysis from a downstream responsibility or by analyzing the pollution heaven hypothesis as presented in Castaneda and Vivanco (2014). However, the methodologies presented in this paper allow to show a different outlook of the real contribution of each country to global GHG generation and especially demonstrate that developed countries have sought new ways of productive organization and trade flows that enable them to report less GHG emissions, which does not reflect their real commitment on the reduction of those gases.

References:

- Castañeda, J. and Vivanco, J. (2014) “Implications of U.S. and China trade in the Green House Gases generation, 2000-2010”. Document presented in 22nd International Input-Output Conference, Lisbon, Portugal.

- Domínguez, A., Parra, J. y Arriagada, O., 2012, "National Economy 2008: a look from the perspective of the linkages for employment matrix size 111 * 111", European Scientific Journal, 8(19): 1-18.

- Kornerup, J., Hoff, E., Peters, G., 2008, "EU consumption, global pollution", WWF's Trade and Investment Programme, Norwegian University.

- Lenzen, M. and Murray J.,2010. “Conceptualizing environmental resposability”, Ecological Economics 70, p.p. 261-270.

- Liu, Y., Jayanthakumaran, K. and Neri, F., 2012. “Who is responsible for the 2012 emissions that China produces?”, Department of Economics, University of Wollongong, Working Paper 08-12, 2012, 24.

- Pan, J., Phillips, J., and Chen, Y., 2008. “China’s balance of emmissions embodied in trade: approaches to measurement and allocating international responsibility” Oxford review of economic policy, Volume 24, Number 2, p.p 354-376.

- Pang, J., Yan, Y., & Wu, S., 2012, “Analysis on CO2 Emission Embodied in Sino-US Trade Based on the GTAP 8. 0 Database”.

- Schiffman, R., 2015. “Brazil’s deforestation rates are on the rise again”. Newsweek, March 22nd.

- Shui, B., and Harriss, R.C. 2006. The Role of CO Embodiment in US-China Trade. Energy Policy 34: 4063-4068.

- Zhou, X. and Kojima, S., 2010. “Carbon Emissions Embodied in International Trade: An assessment based on the multi-region input-output model”, Institute for Global Environmental Strategies and the Grant-in-Aid, Japan Society for the Promotion of Science

Data:

- GHG data from: EORA, *worldmrio.com/*
- Multi-regional input-output matrices from WIOD, *www.**wiod**.org/*